PATENT SPECIFICATION

DRAWINGS ATTACHED

878,480

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COMPLETE SPECIFICATION

A Compacted Foraminous Body Suitable for use as a Sound Attenuating Device.

We, ROCKWELL-STANDARD CORPORATION, a corporation organized and existing under the laws of the State of Pennsylvania, United States of America, of 843 Fourth Avenue, Coraopolis, State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to a compacted foraminous body suitable for use as a sound attenuating device and to methods of producing the same.

The objects and advantages of the present invention will be realized by those skilled in the art to which it pertains by reference to the following description of several preferred embodiments and methods of producing the same and as illustrated in the accompanying drawings wherein:

Fig. 1 is a perspective view of a fragmentary length of tubular knitted metallic mesh used to form the foraminous body of the present invention;

Fig. 2 is a perspective view in an enlarged scale of a section taken from the tubular mesh of Fig. 1 to show more clearly the rectangular configuration of the metallic ribbon forming the same;

Fig. 3 is a vertical elevational view of a length of the tubular knitted mesh of Fig. 1 formed in a cylindrical cartridge prior to compressing the same to form one embodiment of an attenuator device of the present invention;

Fig. 4 is a top plan view of the structure of Fig. 3;

Fig. 5 is a side view, shown partly in section and partly in elevation, of the finished form of one embodiment of attenuator device with the same mounted in a suitable container and ready for placement in a pressure fluid system;

Fig. 6 is a vertical sectional view of a forming die apparatus utilized to form the embodiment of attenuator device shown in Fig. 5 with a cylindrical cartridge structure of Fig. 3 disposed therein prior to compressing the same;

Fig. 7 is a vertical sectional view of the forming die apparatus of Fig. 6 with the same in its fully compressed position and the foraminous structure of Fig. 3 disposed therein and compressed into its compacted form;

Fig. 8 is a perspective view of another embodiment of attenuator device of the present invention with a section cut away to more clearly show the construction thereof; and

Fig. 9 is a vertical sectional view of a forming die apparatus to form the embodiment of attenuator device of Fig. 8.

Briefly, the present invention preferably provides as an attenuator device a foraminous body constructed of a knitted metallic mesh, the latter being formed from a continuous strand of metallic ribbon, rectangular in cross sectional configuration and which mesh is first coiled into a cylindrical cartridge and then compacted under a suitable pressure in such manner that a substantial surface area is presented perpendicularly to a gaseous stream flow passing therethrough and which is then operative to cause a maximum diffusion of said stream flow. The attenuator body, as formed, while effecting a maximum diffusion of said stream flow and hence substantially diminishing the level of audible noise created thereby, permits said gaseous medium to readily pass therethrough without appreciably decreasing its rate of flow.

Referring now to Figs. 1 and 2 of the drawings, there is shown a fragmentary length of knitted metallic mesh, being tubular in form as indicated at A, from which the several embodiments of attenuator device disclosed herein are preferably constructed. Various kinds of metallic material may be utilized to form the knitted mesh, but the more effective results are obtained when using steel, copper,

brass or aluminum; however, it is not intended to define definite limitation as to the particular materials used, others not mentioned herein may be found more desirable for particular applications.

The tubular form is produced by utilizing a continuous strand of metallic ribbon rectangular in cross-sectional configuration, and in which the surface of the wider sides defining the width thereof as indicated at B in Fig. 2 are preferably between .016 and .020 inches, and the shorter sides of said ribbon defining the thickness thereof as indicated at C, are approximately between .005 and .010 inches. The continuous strand of metallic ribbon is extended completely around an axis, for example, as is shown at D, while being loosely knitted or woven into loops E, and advanced longitudinally in a path parallel to the axis D, such that the loops E are interlinked to provide interlaced bights G, wherein the bight of any one loop is interlaced around the adjacent end portions of the bights on the next longitudinally spaced adjoining pair of loops, as is shown in Fig. 2. The rectangular-shaped metallic ribbon is continuously applied in this manner such that its wider sides are disposed somewhat in radial extension from said axis whereby a major part of the maximum surface area of said ribbon lies in planes substantially coincidental with the axis of said tubular form. With the metallic mesh tubular structure thus formed, it is then additionally fabricated to form successive corrugations or crimps on the surface thereof. Several methods may be utilized to perform this operation, for instance, the tubular structure may be first flattened to form superimposed plies and then passed through a crimping machine to form successive crimps extending across the surface thereof preferably at 45 degrees which may if desired be in a nested or non-nested relation depending upon the particular apparatus used in said machine. In the nested relation of the crimps or corrugations the corrugations or crimps on the respective superimposed plies extend parallel to each other with the " crests " of the corrugations on the surface of one ply received within the " troughs " of the corrugations on the opposing surface of the adjacent ply. In the non-nested relation of the crimps or corrugations the corrugations or crimps on the respective superimposed plies may still be parallel to each other but with the " crests " of the corrugations on the adjacent surfaces of the superimposed plies disposed in opposing relation to prevent " nesting " of the corrugations as defined above. Alternatively the non-nested relationship of the plies may be achieved by disposing the corrugations on one ply in non-parallel relationship to the corrugations on the adjacent ply and such a method includes the step of passing the knitted mesh in its tubular form directly through a crimping machine whereby the crimps extend obliquely thereacross at said preferred angle but so disposed that upon flattening of the tubular structure to form superimposed plies the corrugations or crimps on one ply are not parallel to those on the adjacent ply whereby the crimps lie in a non-nested relation. Still another method calls for flattening the tubular structure to form superimposed plies, passing the same through the crimping machine, then separating said plies and again flattening the same so that they are displaced approximately 90 degrees whereby the crimps on the respective plies are non-parallel and lie in a non-nested relation.

Any of the above methods may be utilized to form the crimps on the tubular mesh structure, but must be carried out in such manner that the surfaces of the afore mentioned wider sides B of the metallic ribbon, when forming the superimposed plies, must lie generally perpendicular to the surface of said plies.

With the metallic mesh thus flattened and corrugated, it is next rolled into tight convolute coils to form a cylindrical body or cartridge, as is indicated at K in Fig. 3 wherein the major portion of the surfaces of the wider sides B of the rectangular-shaped ribbon are generally perpendicular to the axis of said cartridge. The obliquely extending lines of crimps or corrugations are indicated at H in Fig. 3 and the outer end of the thus coiled corrugated flattened tubular form is indicated at J in Figs. 3 and 4. It has been found that a completed cylindrical body or cartridge H of substantially four ounces in weight, having a pre-compacted length of approximately four inches and a diameter of three inches provides a sufficient amount of metallic mesh material from which to form the several embodiments of attenuator device of the specific size disclosed herein. It also has been found that a highly effective attenuator device is produced when the knitted tubular form is provided with between fifty and eighty-two loops in each circumferential course of loops.

The formation of the foraminous body of the embodiment of attenuator device shown in Fig. 5, when utilizing the above constructed mesh cylinder or cartridge will now be described.

The cartridge is adapted to be compacted or compressed by a force acting in the direction of its longitudinal axis wherein the layers of the same are disposed edgewise to the direction of said force. The instant method of formation contemplates two distinct compressing steps to obtain the end resultant configuration of foraminous body, and for this purpose it is preferred to use forming die apparatus, as shown in Fig. 6, which includes a female die 8, having an upper elongated cylindrical shell defining a die chamber 9 and rigidly mounting therein an upwardly facing die body 11, which in its present form corresponds to an inverted frustum of a vertical cone. The annular upper edge of the die body is formed to extend sub-

stantially perpendicular to the body axis to define thereby a flat annular flange 12. The peripheral edge 13 of the annular flange on the die body is adapted to abut against the inner annular wall 14 of the cylindrical shell such as to provide a continuous surface within the die chamber 9. The forming die apparatus also includes a male die 16 having die faces complementary to the die faces on the female die body 11, and which is adapted to be actuated in any suitable manner, such as by means of piston 15 attached to the top surface of the latter being actuated by a hydraulic press mechanism, (not shown), to force the male die with suitable compressive action toward and into the female die 8. For the first compressing step the aforementioned cartridge K is placed into the female die chamber 9 and the male die is then actuated to cause it to enter into the female die and partially compress said cartridge into a semi-compacted configuration such as is shown in dot-dash lines at K′ in Fig. 6. The cartridge K, in its semi-compacted form, is then removed from the female die 8 and a screen plate 5 preferably constructed of a suitable metallic screen material such as a 5 loops/inch mesh, and preformed by suitable dies (not shown) similar to the forming dies 8 and 9 into substantially a frustum of a cone, is placed into said female die and against its working surface. The said cartridge is then replaced into the female die, and another screen plate 7 preferably constructed of a 16 loops/inch mesh screen material into substantially the same configuration as that of the screen plate 5, is placed against the working surfaces of the male die 16. Said male die is again actuated to cause it to enter into the female die and compress the above assembled mesh structure therebetween such as is shown in Fig. 7. With the previously described orientation of the wider sides B of the metallic ribbon, i.e., with the surfaces of said sides located perpendicular to the axis of the cartridge K, said surfaces are also disposed perpendicularly to the direction of the force acting on the male die 16. And, as a result, said force assists in retaining the surfaces of the wider sides in this relative position while compacting the cartridge K. In addition, if by chance a part of the rectangular ribbon, while forming the cartridge K, is disposed such that the surfaces of its shorter sides C are perpendicular to the axis of the latter, the force exerted by the male die 16 causes said part to be reoriented while compressing the cartridge K such that the surfaces of the wider sides B thereof are made to lie in perpendicular relationship to said compressing force.

Likewise, as the assembled mesh structure is forcibly compressed and compacted, the convolute coils of the cartridge K are substantially interlocked one with another whereby the mesh openings are substantially reduced so as to provide minute interstices or openings intercommunicating with each other in a tortuous manner. Also, the compressing of the cartridge K tends to interleave portions of contiguous loops thereof and interlock the same whereby the compacted attenuator body partakes of resilient characteristics capable of withstanding considerable gaseous fluid pressure without being substantially deformed. The metallic screen layers 5 and 7 disposed on opposite sides of the compacted body are also effective to resist deformation of the latter. The crossing wires of the screen layers 5 and 7 bite into the ribbon elements of the cartridge K to produce crimps under each individual wire of screens 5 and 7, which further interlock the metallic ribbons of cartridge K. It has been found that a compressive force between 40,000 and 80,000 pounds, depending upon the number of loops provided in the tubular structure, as is hereinabove defined, is sufficient to form the compacted foraminous attenuator body having the required structural and functional characteristics as above described in the specific size device described herein.

In this manner the assembled mesh structure is compacted into a foraminous body P wherein the surfaces of the longer sides B of the metallic ribbon are located generally perpendicular to the axis of the body completely throughout the latter and in addition, the configuration of said body is substantially that of a frustum of a cone having a vertex portion 21 integrally formed with the angularly extending wall 22 thereof to enclose its one end, and an annular flange or rim 23 integrally connected to said wall at the base of said cone and extending substantially perpendicular to said axis.

As previously mentioned, the size of the embodiment of cartridge K disclosed herein in its non-compacted form is approximately four inches in length and three inches in diameter. This particular size is effective when compacted, to form a foraminous body, as described above, having an overall wall thickness of approximately .25 inches, a vertex diameter of substantially .46 inches, a vertical height of approximately 1.44 inches and a base diameter of approximately 3.343 inches. It is, of course, realized that other sizes of non-compacted cartridge may be preferably used when forming sizes and configurations of compacted foraminous bodies other than the embodiment described herein, and hence it is not intended to limit the structural configuration of the present invention to the disclosed form.

The foraminous body P thus formed may then be placed into a suitable container, such as is indicated at 24 in Fig. 5, which in its present configuration is substantially cup-shaped, having a circular base 25 integrally connected at its periphery to an upstanding annular wall 26, defining therebetween a cavity or chamber 27. The free end of the annular wall 26 is integrally formed with a radially outwardly extending channel 28 into which the annular rim 23 of the foraminous body is

adapted to be seated and secured such that the interior conical surface of the latter faces and is open to the container chamber 27. The base 25 of the container also centrally mounts an externally threaded hollow sleeve 29 communicating with the container chamber 27 and which enables the attenuator device to be connected in circuit with a pressure fluid system so as to intercept its fluid stream flow.

The presently assembled form of attenuator device is especially designed for use with pneumatically operative units such as air motors, tools and the like to attenuate or reduce the level of audible noise created by the exhaust gaseous medium stream flow. For this purpose the attenuator device is placed directly into the exhaust circuit of the latter by means of the aforementioned threaded sleeve 29 such that the exhaust air stream flow enters into the container chamber 27 and is directed toward the interior conical surface of the foraminous body P. Said stream flow thence impinges upon the communicating surfaces of the longer sides B of the metallic ribbon forming said foraminous body, and is thereby rapidly dispersed throughout the tortuously connected interstices of said body to atmosphere in such manner that the shock waves created by said flow are substantially dissipated, resulting thereby in a substantial reduction in the level of the audible noise produced by the latter.

The instant form of attenuator device is also adapted to be placed into the gaseous fluid intake circuit of a pneumatically operative unit of the class referred to wherein the intake gaseous stream flow is of such velocity as to create a high level of audible noise. For this purpose, the sleeve 29 may be threadably attached to the intake circuit of the unit so that the gaseous medium is first drawn into the foraminous body of the attenuator device, passing through the tortuously connected interstices thereof such as to prevent a tendency of said gaseous medium to build-up into a definite unitary pattern. Said gaseous medium passes into the container chamber 27 and then through the sleeve 29 to said connected intake circuit to thereby provide a supply of gaseous medium to said pneumatically operative unit.

In the embodiment of foraminous body R shown in Fig. 8, the reinforcing screen plates 5 and 7 are replaced by intersecting radially and circumferentially extending ridges and grooves 33 and 34 respectively, formed integrally on the opposed surfaces of the compacted foraminous body and which effect an interlocking of the metallic ribbons in the device, with consequent reinforcement of the latter, and thereby these ridges and grooves tend to prevent its deformation due to a high velocity and/or pressurized gaseous medium stream flow therethrough.

For this purpose, the working surface 38 of the male die 39 in the forming die apparatus as is shown in Fig. 9, which is preferably used to form the present embodiment, is provided with a series of concentric, circumferentially extending ridges 41 which intersect at spaced points on said surface with a series of similarly shaped ridges 42 radiating along the slanting sides of said surface from the vertex portion 33′ of said male die.

The female die 45, likewise is provided on its working surface 47 with a series of concentric, circumferentially extending grooves 48 which also intersect at spaced points with a second series of grooves 49 identical in configuration but radiating along the slanting sides of said die surface from its lower vertex portion 51.

With the forming die apparatus constructed as above described, the cartridge K is placed endwise into the female die chamber 9 and the male die 39 is then actuated to compress said cartridge into its compacted form to provide a unitary reinforced foraminous attenuator body R which is durable and self-sustaining in construction and hence highly resistant to mechanical deformation.

In actual use the several forms of attenuator device of the present invention, constructed in the manner described herein, have been found to operate much more effectively than presently accepted prior art devices of this type in attenuating the noise level of a gaseous stream flow without substantially diminishing the rate and/or pressure of said flow. For example, the operation of a pneumatically operated unit with the instant attenuator device in its air intake circuit was compared with the operation of the same unit while using a device representative of the prior art devices. In said comparative operation the rate of flow of the air intake, and likewise the frequency of said flow were varied throughout a wide range to give a more comprehensive picture of the highly efficient operation of the instant form of attenuator. In addition, a plurality of different attenuator devices of the present invention were used, each having a different width and thickness of metallic ribbon to clearly illustrate the highly effective operation of the particular device wherein the size of the metallic ribbon is within the structural dimensions noted hereinabove, namely, a width within the limits of .016-.020 inches and a thickness of .005-.010 inches. In like manner, the attenuator body in each of the instant selected devices was compacted under a pressure of approximately 60,000 pounds, which is substantially in the middle of range of compressive force noted hereinabove.

The operational results obtained are as noted in the following chart:

Intake Pressure Drop in "Inches of H_2O"										
Air Flow in Cu. Ft./Min.		2	4	6	8	10	12	14	16	18
Present Attenuator Device Ribbon Thickness .007 In.										
Width of Ribbon, Inches:	(a) .025	2.7	6,3	11.4	17.4	25.1				
	(b) .016	.5	1.2	2.2	3.6	5.2	7.2	9.4	11.6	14.0
Accepted Prior Art Device		1.0	2.4	4.1	6.4	9.1	12.6	16.5	20.5	24.8

Sound Pressure Level in "Decibels"							
Frequency of Air Flow in Cycles/Sec.		212	425	850	1700	3400	6800
Present Attenuator Device Ribbon Thickness .007 In.							
Width of Ribbon, Inches:	(a) .023±.002	45	44	40	38	43	39
	(b) .018±.002	53	49	45	45	54	52
Accepted Prior Art Device		54	50	48	55	60	60

Referring to the above operational results, it is seen that in the attenuator device of the present invention using a ribbon dimension of .007 x .025 (noted as "a" in each test), the level of the audible noise, as measured in decibels, is reduced to a level substantially below the level attained by using the prior art device; it is also seen that the air intake, however, flows through the instant device with a greater pressure drop in inches of H_2O than when using the prior art device.

However, with an attenuator device of the present invention using a metallic ribbon having dimensions within the limits established hereinabove, namely, a thickness of .007 inches and a width of .016 to .020 inches (noted as b in each of the tests), the pressure drop in the air intake flow is approximately half as much as is experienced with the prior art device, and likewise, the level of the audible noise is decreased to a value below that attainable with said prior art device.

Therefore, it is seen that if the width of the metallic ribbon is increased to a value above the accepted range (.016-.020 inches), the level of the audible noise is substantially reduced, but the pressure of the air flow is also greatly diminished. Carrying this analogy still further to an extreme, it is reasonable to say that if the attenuator device was formed of a solid material, the noise level would be reduced to almost zero, but at the same time, no air would be able to flow through the intake circuit.

Hence, by constructing the attenuator device of the present invention using a metallic ribbon of rectangular section whose dimensions are in accordance with the definite limits as are established herein, the noise level of the air intake flow is reduced to a level which, for all frequencies measured, is below that attainable by the prior art device, and at least as low a pressure drop in the air intake flow as is experienced with said latter device.

It is therefore apparent that an attenuator device constructed in the manner hereinabove described and shown, having a compacted foraminous body made from a continuous strand of metallic ribbon rectangular in section, and wherein the surfaces of the longer sides of said ribbon are located generally perpendicular to the axis of said body, presents a maximum surface area to a gaseous stream flow directed to either of its conical surfaces in the direction of said axis, and is thence effective to substantially attenuate or diminish the level of audible noise produced by said stream flow.

It is also apparent that the attenuator device of the present invention is maintained at a substantially high rate of efficiency by reason of the fact that the compacted foraminated construction of the same acts to retain the longer sides of the metallic ribbon in their operative position such that a maximum surface area of said device is always presented to a gaseous medium stream flow passing therethrough.

It is also realized that the attenuator device of the present invention, as processed and formed in the manner herein described, is provided with a unitary compacted foraminated construction having a plurality of tortuously connected minute interstices which are substantially permanently located throughout said device to enable a relatively constant volume of gaseous medium to pass therethrough.

Having thus described several preferred embodiments of the present invention, it is realized that the same is susceptible of various modifications without departing from the in-

ventive concepts defined herein and as set forth in the claims.

WHAT WE CLAIM IS:—

1. A compacted foraminous body for use e.g. as a sound attenuating device, the body comprising a continuous thin metallic ribbon rectangular in section forming a plurality of contiguous interconnected loops about a predetermined axis, the greater portion of the surface of the rectangular ribbon being in a generally perpendicular orientation with respect to the axis of the body.

2. A foraminous body according to claim 1, wherein said ribbon is knitted into an elongated tubular form of knitted mesh, said mesh prior to compaction being rolled into a cylindrical cartridge, and wherein after compaction the great majority of the wider sides of the ribbon are in substantially perpendicular orientation with respect to the axis of the cartridge.

3. A foraminous body according to claim 2, wherein the cartridge is compressed into a tightly compacted substantially conical configuration.

4. A foraminous body according to claim 3, wherein the compressed cartridge is in the shape of a frustrum of a cone having a flat vertex portion integrally formed therewith closing one end of the cone, the great majority of the surfaces of the ribbon throughout the body and vertex portions being generally perpendicular to the axis of the body.

5. A foraminous body according to claim 4, including an annular rim formed on the end of the cone remote from the vertex portion, the vertex portion and the rim being in generally perpendicular orientation with respect to the axis of the body, the great majority of the surfaces of the wider sides of the ribbon throughout the rim being generally perpendicular to the axis of the body.

6. A foraminous body according to any of claims 3 to 5, including a plurality of reinforcing ribs integrally formed on one conical surface of the body and intersecting at spaced points with a plurality of transversely extending similarly reinforcing ribs.

7. A foraminous body according to claim 6, wherein the first said plurality of ribs is concentrically arranged, the second said plurality of ribs radiating longitudinally along the said surface from one end of the body.

8. A foraminous body according to any of claims 3 to 7, including a plurality of reinforcing grooves concentrically integrally formed on a conical surface of the body and intersecting at spaced points with a plurality of similarly shaped grooves radiating longitudinally along the latter surface from one end of the body.

9. A foraminous body according to claims 7 and 8, wherein the ribs are formed on one conical surface of the body, and the grooves are formed on another conical surface of the body.

10. A f raminous body according to any of claims 2 to 9, including a foraminous plate disposed over each end of the cartridge to form a composite mesh structure upon compression thereof.

11. A foraminous body according to any preceding claim, wherein the ribbon has a width in the range of between .016 and .120 inches and a thickness in the range of between .005 and .010 inches.

12. The method of producing a foraminous body which comprises the steps of forming metallic mesh from a single strand of thin metallic ribbon generally rectangular in section, folding the mesh into tight convolute coils to form a cylindrical cartridge wherein the surfaces of the wider sides of the ribbon are generally perpendicular to the axis of the cartridge, and compressing the cartridge endwise upon itself into a tightly compacted body, the great majority of the said ribbon surfaces being dispersed throughout the body in perpendicular relation to the axis of the body and spaced to form a plurality of minute tortuously connected interstices.

13. The method according to claim 12, including flattening the mesh into a plurality of interconnected superimposed plies, the said surfaces of the ribbon being generally perpendicular to the plane of each of the plies, and rolling the plies into the said tight convolute coils.

14. The method according to claim 13, including forming corrugations on the mesh extending obliquely to its axis, the corrugations being in non-nested relation after flattening of the mesh.

15. The method according to any of claims 12 to 14, including placing the cartridge into a forming die structure, the compression being by means of an axially directed force which imparts a conical configuration to the body.

16. The method according to claim 15, wherein reinforcing ribs and grooves are formed on the surfaces of the body during compression.

17. A compacted foraminous body substantially as illustrated by Figs. 1 to 5 of the accompanying drawings, and as described with reference thereto.

18. A sound-attenuating device substantially as illustrated by Fig. 5 of the accompanying drawings, and as described with reference thereto.

19. A sound-attenuating device substantially as illustrated by Fig. 8 of the accompanying drawings, and as described with reference thereto.

20. The method of producing a compacted foraminous body substantially as described hereinabove.

MARKS & CLERK.

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878,480 COMPLETE SPECIFICATION
3 SHEETS
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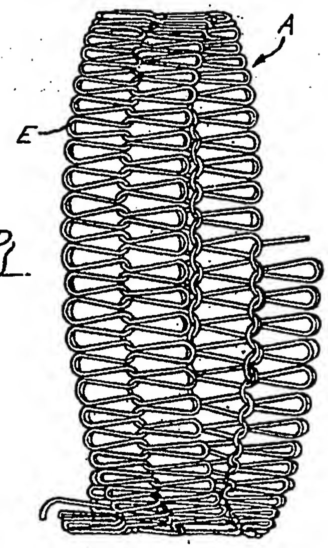


Fig 1

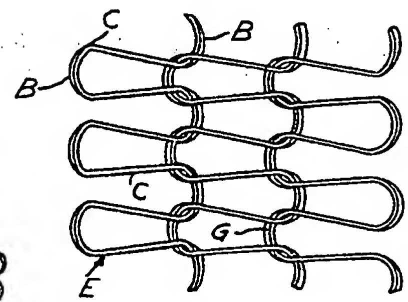


Fig 2

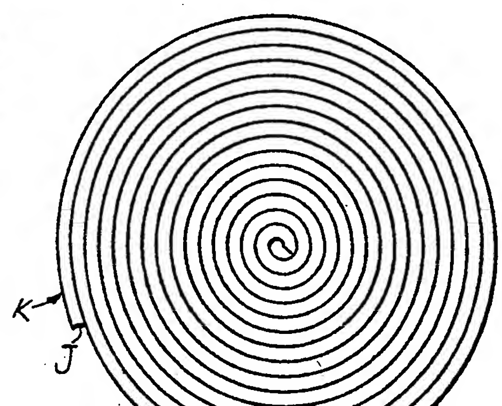
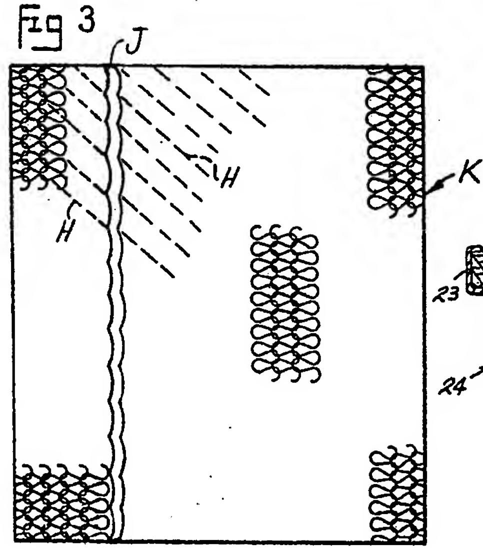


Fig 4

Fig 3



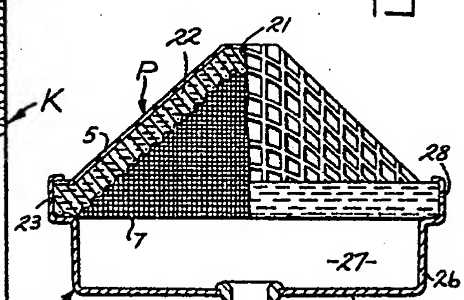


Fig 5

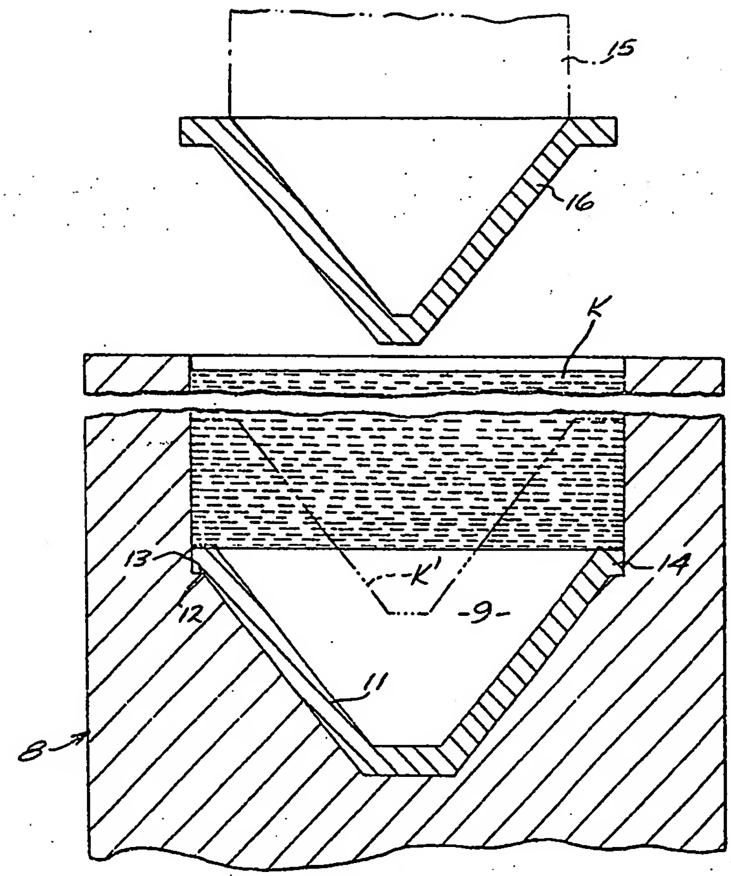


Fig 6

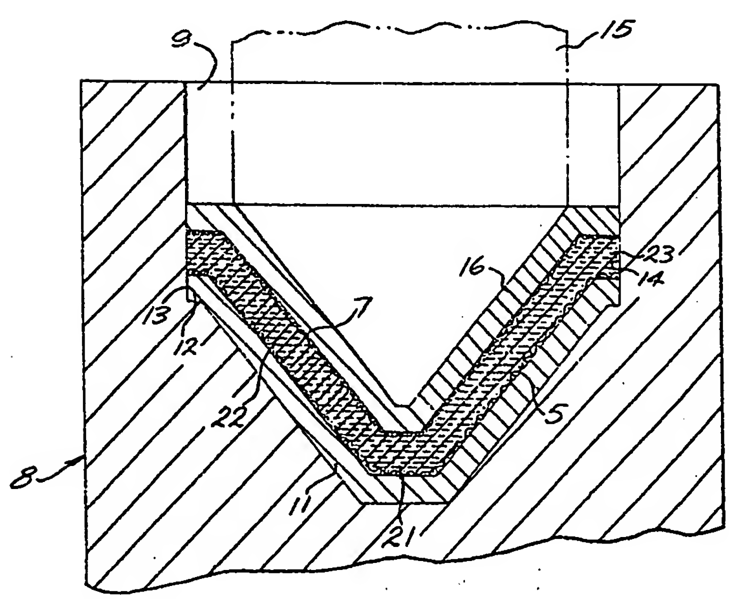


Fig 7

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SHEETS 2 & 3

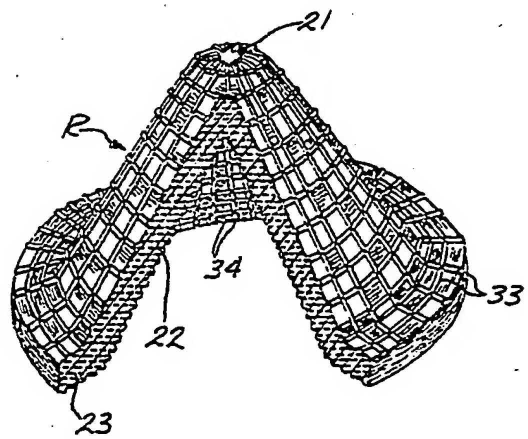

Fig 8

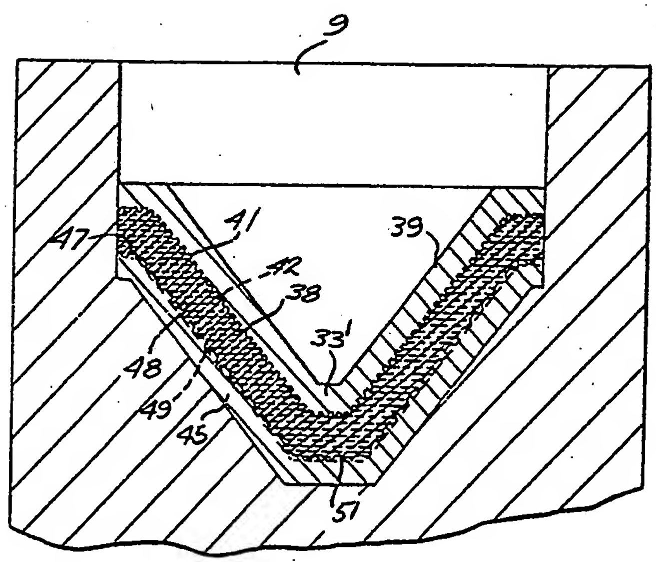

Fig 9

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SHEETS 2 & 3

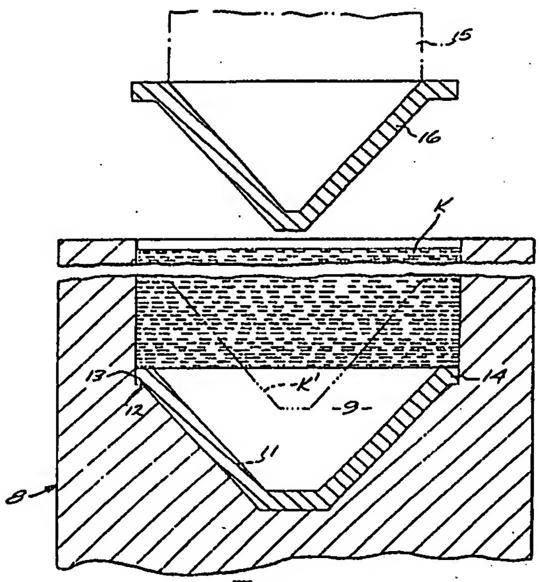

Fig 6

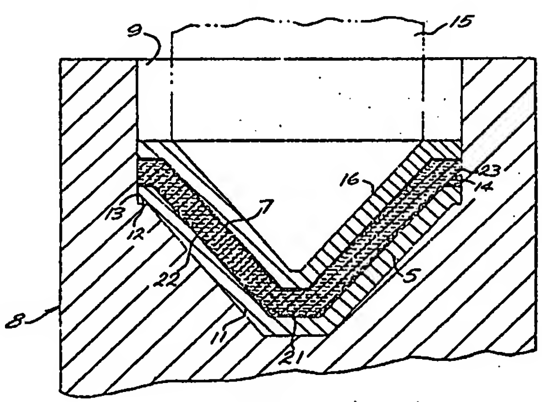

Fig 7

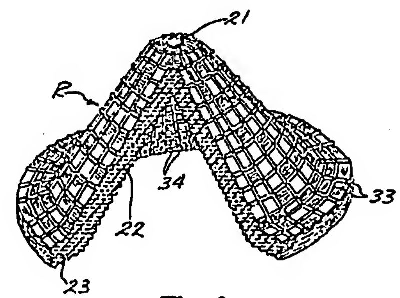

Fig 8

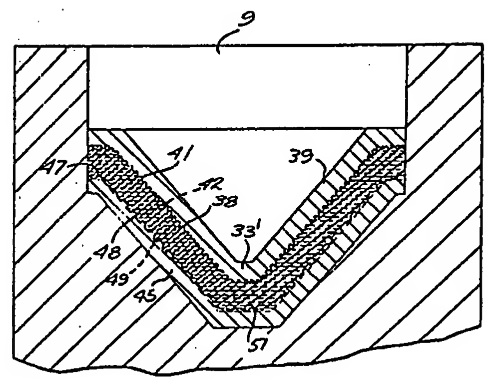

Fig 9